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JPRS L/9035

16 April 1980

USSR Report

MATERIALS SCIENCE AND METALLURGY

(FOUO 3/80)

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USSR REPORT

MATERIALS SCIENCE AND METALLURGY

(FOUO 3/80)

This serial publication contains articles, abstracts of articles and news items from USSR scientific and technical journals on the specific subjects reflected in the table of contents.

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NUCLEAR SCIENCE AND TECHNOLOGY

REACTOR MATERIAL TECHNOLOGY

Moscow REAKTORNOYE MATERIALOVEDENIYE in Russian, 1979 signed to press 27 Dec 78 pp3, 343-344

[Foreword and table of contents from book by D. M. Skorov, Yu. F. Bychkov, A. I. Dashkovskiy, Atomizdat, 2080 copies, 344 pages]

[Text] Foreword to second edition

The "Reactor Material Technology" monograph published in 1968 was sold out rapidly which indicates reader interest in this book. In the years after the book was published many publications appeared in the Soviet Union and abroad that considerably expanded our concepts on the properties of reactor meterials,and on the mechanism of the processes occurring in these materials during their use.

The second edition of this book was rewritten taking into account the latest data on the physical, mechanical and nuclear properties of uranium, plutonium and thorium, as well as of their compounds.

As before, basic attention is devoted to the description of nuclear fuel and structural materials, the processes occurring in them under the influence of radiation and other factors related to operating conditions. Along with this, problems are more fully considered of the change in the most important properties, identifying the patterns of such changes that would make it possible to outline ways to improve the operating characteristics of the materials. Problems are elucidated of the life of the jacket (structural) materials, in particular of the importance of strength properties and their relationship to the formation and precipitation of helium when irradiated, problems of corrosion etc.

In connection with a great number of new data and the necessity of more detailed treatment of the material technology and metal physics aspects of reactor materials, the authors considered it expedient to eliminate sections of the book concerning physical and thermophysical problems of the active zone of the reactor.

In the second edition being offered, the general structure of the book, the order and titles of several chapters and sections were preserved; however, the contents are completely renewed, the majority of chapters were newly written taking into account new data, while the remaining chapters were rewritten and amplified considerably.

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POLYMER MATERIALS

STRUCTURE AND PROPERTIES OF POLYMER MATERIALS

Riga AKADEMIYA NAUK LATVIYSKOY SSR INSTITUT MEKHANIKI POLIMEROV (Academy of Sciences Latvian SSR Institute of Polymer Materials) in Russian, 1979 signed to press 27 Oct 77 pp 5-8, 207-208

[Foreword and table of contents from the book, "Zinatne," 222 pages]

[Text] In the course of scientific and technical progress there is all the more growth in requirements for structural materials. This was reflected in the resolutions of the 25th Congress of the CPSU where they talked about the development of new polymer materials and improved quality of existing ones. To meet these tasks will require further development of structure research and determination of the relationships between the structural constitution and a complex of physical and mechanical characteristics of polymer materials; to control the process of polymer synthesis will require structural research at the solutions level. Determination of the correct mode of material application in turn is not possible without knowledge of structural transformations during the action of a varying form of external factors on the polymer material. All of the above-listed problems were examined in detail at the Third All-Union Conference on the Mechanics of Polymers which was held in 1976 in Riga and reflected in the transactions put forward to the reader of the collection.

The content of articles in the first part of the collection encompasses a broad circle of questions associated with the structure of a polymer material at different structural levels. All the work on the problems and produced results can be reduced to the following basic directions: 1) uncovering new principles of structure and property relationship and 2) development of new methods for controlling structure and the properties associated with it. Most works have been associated with study of the structural state of polymers at various levels.

Recently more attention is being given to properties characterizing the system of macromolecules as a whole--like molecular mass, molecular-mass distribution, etc. In conjunction with this exists the necessity to conduct experimental and theoretical research, determine the nature of the relationships between molecular distribution and individual structural elements such as the presence of vacancies, number of through molecules, etc. The work of V.P. Budtov and L.M. Terent'yeva is devoted to this research, where the number of through chains in relation to the degree of polydispersion can be determined in partially crystalline polymers.

The expansion in the use of composite materials requires more rigorous research of cellular polymers as the material forming the composite matrices of a composite. The articles of B.A. Rozenberg and V.I. Irzhak, A.A. Askadskiy, Yu. S. Kochergin, L.I. Komarova, S.N. Salazkin, I.A. Bulgakova, G.L. Slonimskiy, S.V. Vinogradova and V.V. Korshak, I.I. Operchuk and A.V. Morozov deal with the study of their structure. In these works the structural organization of the lattice at different levels of evaluation is described, the relationship of structure characteristics with the characteristics of mechanical properties of the polymer is shown and an evaluation of the meaningfulness of the chemical structure is given along with determination of its effect on mechanical properties; a method of determining glass transition temperatures according to the chemical structure characteristics is proposed.

The articles of V.I. Vettergen', L.S. Dzyubenko, V.V. Nizhnik and V.P. Solomko, N.N. Maleyev, N.S. Tsvetkov and I. Ye. Tvardon are also devoted to problems of developing composite materials in which the behavior of macromolecules in boundary layers is investigated.

Interesting results were produced in the work of A.I. Kulakov and V.I. Prosvirin; they tested fluoroplastic at the temperature of its normal environment and the corresponding phase transformation simultaneously.

New concepts on the structure of amorphous polymers are given in the work of B.Ya. Mar'yasin, S.D. Koshelev, A.I. Krivonosov and I.I. Perepechko. They observed regions with a high degree of structure ordering in which there also existed two levels of permolecular organization.

The need for research into determining the relationship between the structure of polymers and their wear is quite urgent. Articles of V.V. Korshak, I.A. Gribovaya, A.V. Vinogradov, A.P. Krasnov and A.N. Chumayevskaya are devoted to development of a self-lubricating plastic possessing high thermal stability. Results of this research made it possible not only to select the best composition but also to formulate a series of requirements to individual components.

In the work of S.B. Aynbinder, F.Dzhalilov and K.I. Tsirule it is shown that as a result of low pressure friction in polyethylene the degree of crystallinity is diminished in the surface layers and the concentration of transisomers is increased whereas for polyethylene under high pressure these characteristics are practically unchanged. Detailed research in development of antifriction materials is extremely important.

Articles in the second section of this collection reflect results of finding relationships between the mechanical properties of the finished material and the indicators of the molecular or permolecular structure produced in the production process. The greatest successes in solving the problem of finding the mechanical properties of polymers according to the indicators of its molecular structure can be achieved by studying solutions and melts. The conducting of such research on objects in which a developed permolecular structure is absent opens a new region of practical use of polymer rheology at flow temperatures. Besides the traditional region of use, including consideration of technological processes based on flow, the rheology of liquids becomes the tool for monitoring and controlling the processes of synthesis and reprocessing polymers with a goal of providing a product with given properties for minimum changeability of operational qualities.

The articles of I.P. Briyedis, V.V. Leytland, V.N. Burliye, M.P. Platonov, A.L. Gol'denberg, N.M. Domareva, B.S. Polonskiy, A.S. Naumenko, L.F. Shalayeva and P. Adamskiy are devoted to studying the relationship of polymer mechanical properties to the molecular structure indicators in the flow temperature region. In the article of I.P. Briyedis and V.N. Burliye a model is proposed for calculating the visco-elastic characteristics of a polidispersed polymer according to the characteristics of molecular-mass distribution. The proposed model is based on the additivity of molecular mass. In the article of I.P. Briyedis and V.V. Leytland the steady-state process of stressing a polymer, determining the properties of a stretched fiber, can be described by the visco-elastic properties. Relationship of the latter to the molecular structure indicators makes it possible to predict the properties of the finished product and to control the stretching process in relation to the solution molecular structure.

Authors of the works listed above start from the premise on the linear relationship between strains and stresses. The work of A.S. Naumenko was founded on the concept of non-linear deformation which in turn was made on the basis of statistical methods of establishing the link between the effective viscosity and molecular-mass distribution in the mode of polymer steady-state flow.

The correspondence between polymer viscosity and its molecular mass under conditions of the polymer diluted with a low molecular substance is examined in the work of L.F. Shalayeva.

Interesting results are presented in the work of V.M. Platonov and coauthors where it is shown by the results of investigation of the mechanical properties of high-pressure polyethylene that such a parameter as the magnitude of high-elastic deformation at high temperatures is more sensitive to molecular-mass distribution than the standard physical-mechanical indicators.

The work of P. Adamskiy can be related to research of individual macromolecules according to results of testing polymer solutions.

The remaining works of this section are devoted to problems of developing materials with new, needed properties by means of acting on the permolecular structure of a material. Thus, Ye. S. Solodyshev, R.A. Turusov, E.F. Oleynik and G.D. Andreyevskaya showed how heat treatment changes the properties of network polymers. I.P. Dashkevich and M.A. Prutskaya investigated the effect of an electrical discharge on the tensile strength of polyethylene. In the work of Yu.S. Zuyev, M.F. Bukhina and A.Z. Borshchevakaya an attempt was made using filled elastomers to evaluate the boundary layer properties by the change in thermal expansion. T.D. Shermergor presents the results of computing the effective modulus of elasticity for a microheterogeneous two-component composite according to the known properties of the constituents. Yu.V. Nikitin and V.P. Budtov analyze data on permolecular orientation and examine the mechanism of strengthening shock-resistant polystyrene. They raise the question on the heterogeneity of matrices of multiphase systems and come to the conclusion that the hypothesis about a single-phase matrix cannot be rightfully acknowledged.

Study of the mechanisms of aging, deformation and failure of polymer materials is necessary for predicting their behavior in application and for establishing means of improving their properties. Research, directed toward solving these problems, is presented in the third section. Information is presented on the behavior of materials during extensive use and on changes in structure due to temperature changes and ultraviolet irradiation. The problem of predicting polymer properties during a multi-stage process is examined. The features of crack formation in organic glass over an extended period are studied and an interpretation of these features is given. The basic principles of laser failure of polymers are presented and a physical model of this process is constructed. The possibility of using nuclear magnetic resonance spectra for determining the function of macromolecule distribution in length is shown.

Undoubtedly the readers of this collection of articles will be enlightened by the new data on the structure of polymers, and researchers will also benefit, especially those working in the fields of theoretical mechanics, as well as design engineers.

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RUTHENIUM

PHYSICAL CHEMISTRY OF RUTHENIUM AND RUTHENIUM ALLOYS

Moscow FIZIKOKHIMIYA RUTENIYA I YEGO SPLAVOV (Physical Chemistry of Ruthenium and Its Alloys) in Russian 1979 signed to press 28 May 79 pp 3-4, 228-229

[Introduction and table of contents from book by M. V. Rayevskaya and Ye. M. Sokolovskaya, Izdatel'stvo Moskovskogo universiteta, 840 copies, 230 pages]

[Text] Introduction

In connection with solving the problem of developing materials for new technologies, corrosion-resistant and refractory metals of the platinum group (ruthenium in particular) and their alloys are attracting considerable attention.

The chemical and electrochemical industry, automatic control and measuring equipment, radio engineering and electronics are the principal users of the noble metals in modern technology.

A stated task in specialized instrument engineering, alongside that of developing new alloys with special properties, is that of replacing short-supply platinum, rhodium, iridium and their alloys with more readily-available materials.

Ruthenium is positioned in Group VIII of V. I. Mendeleyev's Periodic System and consequently has the same structure in its outer electron shell as platinum, iridium and the other elements of this group, and since the electron structure of elements determines the physicochemical properties of metals, ruthenium possesses all properties characteristic of metals of the platinum group -- refractoriness, high strength properties, high corrosion resistance, etc. and, alongside palladium, is the most readily available and inexpensive.

Although systematic investigation of alloys of ruthenium began comparatively recently, ruthenium alloys have already gone into widespread use. For example, ruthenium is an effective hardener of platinum and palladium. Addition of ruthenium to some metals improves their properties: 0.1-1 percent ruthenium increases the machinability of molybdenum melted in an arc furnace, while the addition of 0.1 percent ruthenium to titanium increases its corrosion resistance in reducing media 100-fold. Ruthenium catalysts present considerable interest.

All the possibilities of ruthenium utilization, however, have not been fully determined, since the chemistry of ruthenium and its alloys has not been sufficiently studied.

At the present time neither the Soviet nor foreign literature contains a systematic survey on the chemistry of ruthenium, including the latest literature data. The following books: "Khimiya ruteniya" [Chemistry of Ruthenium], Prof O. Ye. Zvyagintsev, editor, 1965; and "Metallovedeniye platinovykh metallov" [Physical Metallurgy of the Platinum Metals], by Ye. M. Savitskiy, V. P. Polyakova et al, 1975, deal only with certain aspects of the chemistry and physical metallurgy of ruthenium. The authors of this present study have endeavored to fill in this gap. This volume contains data of the authors and from the literature on the physical chemistry of ruthenium and ruthenium alloys. Special emphasis is placed on the corrosion properties of alloys, as representing the greatest practical interest.

This volume can be of use to scientific investigators working in the area of the noble metals, as well as undergraduate and graduate students specializing in this area. The authors hope that this volume will make the job of developing new ruthenium-base alloys easier for specialists working on the creation of new materials.

The authors would like to express their sincere thanks and gratitude to laboratory personnel T. P. Loboda, T. A. Spitsyna, A. L. Tatarkina, Ye. P. Karatygina, and A. D. Yevdokimova for their assistance in preparing the manuscript, as well as to graduate students S. V. Kabanov, N. Ye. Yefremenko, and L. K. Kulova for their assistance in putting the manuscript into publishable form.

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SILVER

SILVER AND SILVER-BASE ALLOYS

Moscow SEREBRO, SPLAVY I BIMETALLY NA YEGO OSNOVE (Silver and Silver-Base Alloys and Bi-Metals) in Russian 1979 signed to press 6 Mar 79 pp 3-4, 295-296

[Foreword and table of contents from book by V. A. Masterov and Yu. V. Saksonov, Izdatel'stvo Metallurgiya, 8,800 copies, 296 pages]

[Text] Foreword

Each year more than 10,000 tons of silver are consumed in the production of strip, foil, sections, wire, tube, press forgings, and powder metallurgy.

Silver is particularly essential for branches which manufacture precision machinery, equipment, electrical, radio and electronic equipment, and high-quality consumer goods. Silver is extensively employed in medicine.

Specialized plants for processing noble metals produce approximately 400 silver-base alloys and composites: there are tens of thousands of types and sizes in metallurgical unfinished and finished goods. Efficient and economical utilization of silver-containing products promotes rapid growth and development of the leading branches and sectors of the economy and produces enormous technological and economic effect in the metallurgical industry and with consumers.

This reference volume deals with the manufacture and efficient utilization of finished and unfinished products of silver and silver-base alloys. This is the first such volume to be published in the Soviet Union. The authors have included information from approximately 500 sources; 300 of them have come out since publication in 1964 of the famous textbook by V. A. Golovin and E. Kh. Ulyanova entitled "Svoystva blagorodnykh metallov i splavov" [Properties of Noble Metals and Alloys] [1].

This reference book devotes considerable attention to studies by Soviet specialists Ye. M. Savitskiy, N. N. Frantsevich, Ye. S. Shpichinetskiy, A. A. Rudnitskiy, I. P. Melashenko, V. V. Usov, V. M. Rozenberg, N. L. Pravoverov, V. P. Andronov, S. F. Lashko, A. A. Kuranov, I. T. Filenko,

I. M. Nikol'skaya, G. A. Mochul'skaya and others, as well as foreign specialists -- M. Spengler, U. Harmsen, G. Reinacher, A. Keil, E. Raub, M. Ashby, K. Schroeder, M. Besterci, E. Gebhardt, H. Schreiner, D. Stoeckel, J. Meijering, W. Koester, and others.

Reflected in this reference book is the production know-how of modern Soviet and foreign enterprises; emphasis is placed on examination of the problems of production and employment of silver-base metal products. Recommended specialized literature is listed for related topics (electro-deposition technology, photographic materials, jeweler's art, soldering, etc).

Chapters 1, 6, and 7 are written by V. A. Masterov and Yu. V. Saksonov, with the remainder written by V. A. Masterov.

The authors would like to express their sincere thanks to the experts at Soyuzzoloto of the USSR Ministry of Nonferrous Metallurgy, as well as Doctor of Technical Sciences V. M. Rozenberg and candidates of technical sciences A. A. Kuranov, Ye. S. Shpichenetskiy, S. G. Khayutin, I. M. Nikol'skaya, G. A. Mochul'skaya, and V. P. Fedorenko for their valuable recommendations, and to Candidate of Technical Sciences I. I. Gul'tyay for productive discussion of a number of items presented in this volume; the authors would also like to express their thanks to translator V. M. Namestnikov for his help in preparing materials. Valuable suggestions were made by Candidate of Technical Sciences G. S. Khayak in editing the manuscript.

Original materials on silver-base bi-metals presented in this volume are to a considerable degree the result of research involving the participation of Candidate of Technical Sciences Yu. A. Voropayev, as well as M. M. Shalyapin, V. I. Kuznetsov, M. L. Kantor, G. A. Postnikova, L. V. Kucheryavaya, V. A. Semina, and L. G. Vyal'shina. Incorporation of these materials was made possible thanks to the efforts of a large production team, and in particular I. A. Andryushchenko, I. A. Krasnosel'skiy, B. F. Zubov, A. F. Spiridonov, I. B. D'yakonov, V. P. Rumyantseva, A. F. Starozhuk, P. M. Yefremova, V. P. Ryabov, V. I. Pechenkin, and many others.

The following symbols for basic quantities are employed in this volume:

%, % (at.), % (vol.) -- percentage content of a constituent by mass, atomic, by volume; γ -- density, g/cm^3; ρ -- specific electrical resistance, microhms/cm; Λ -- thermal conductivity, cal/(cm·s·°C); λ -- electrical conductivity, m/(ohms per mm^2); χ -- mass magnetic susceptibility, cm^2/g; σ_B -- tensile strength, kg/mm^2; δ -- percentage elongation after failure; ψ -- reduction of area, %; E -- modulus of elasticity, kg/mm^2; G -- shear modulus, kg/mm^2; σ_T -- yield point, kg/mm^2; σ_τ -- rupture stress, kg/mm^2; σ_{-1} -- fatigue strength, kg/mm^2; $\sigma_{пц}$ -- proportionality limit, kg/mm^2; σ_S -- resistance to plastic deformation, kg/mm^2; Θ -- temperature, °C; T -- temperature, K; η -- dynamic viscosity, centipoise; HB, HV, H_μ -- Brinell hardness, Vickers hardness, microhardness, kg/mm^2;

$\varepsilon = \frac{H_0 - H_1}{H_0} = \frac{l_1 - l_0}{l_0}$ -- relative deformation with change in thickness from H_0 to H_1 (or length from l_0 to l_1).

The following table contains conversions of non-system units to International System units.

Designation of Quantity	Metric Units	International System Units
Stress	kg/mm^2	~10 MPa
Pressure	at	~0.1 MPa
Quantity of heat	cal	4.1868 J
Thermal conductivity	cal/(s·cm·°C)	418.68 w/(m·K)
Specific heat	cal/(g·°C)	4.1868 kJ/(kg x K)
Specific electrical resistance	ohms per mm^2/m	10^{-6} ohms/m
Density	g/cm^3	$1000\ kg/m^3$

Contents

[101-3024]

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TITANIUM

UDC 620.194

CORROSION CRACKING OF TITANIUM AND ALUMINUM ALLOYS

Kiev KORROZIONNOYE RASTRESKIVANIYE TITANOVYKH I ALYUMINIYEVYKH SPLAVOV in Russian 1979 signed to press 20 Feb 1979 pp 2-4, 128

[Annotation, foreword and table of contents from book by Melekhov, R.K., candidate of technical science,2400 copies, Tekhnika, 128 pages]

[Text] Problems are elucidated of corrosion cracking of titanium and aluminum alloys in gas and liquid media -- halogens, water, methyl alcohol and its vapors, acid solutions and several other media. Salt corrosion of titanium alloys is considered. An analysis was made of factors that affect the process of corrosion cracking of titanium and aluminum alloys; methods were described for determining their tendency to corrosion cracking, and recommednations are given for eliminating this type of destruction under industrial conditions. The monograph is intended for scientific workers concerned with problems of the lasting strength of structural components and their protection against corrosion, and may also be useful to engineers, technicians and VUZ students of respective specialties. Tables 17. Illustrations 53. Bibliography has 105 titles.

Foreword

One of the trends that determine the long range prospects of economic development, as stressed at the 25th party congress, is increasing the share of aluminum, titanium and polymers in the total output of structural materials which is dictated by the necessity of reducing materials consumption in all sectors of industry. A considerable reduction in metal consumption for equipment, preserving at the same time the unit strength and increasing the corrosion-mechanical resistance is possible by using higher-strength titanium and aluminum alloys in which strength properties are combined with low specific weight. Titanium alloys are promising for structural components operating at temperatures higher than 250°C when light aluminum alloys soften.

Having a high corrosion resistance in a number of corrosive media, titanium and its alloys compete successfully with traditional materials in such industrial sectors as chemical, petroleum, shipbuilding, food, chlorine and nonferrous metallurgy. Titanium and its alloys are used to manufacture parts of gas-turbine engines and ships, equipment for tankers, pumps and hardware for pipelines, autoclaves, evaporators, etc. The list of equipment made of titanium and its alloys in a nonferrous metallurgy alone has over 200 names.

At present, considerable experience has been accumulated in operating equipment made of aluminum alloy structural components in various industries, including light and food industries, and petroleum and gas production. However, the low mechanical strength of aluminum alloys does not meet modern requirements of the material of a number of products for which light alloys must be used. The development and use of new high-strength aluminum alloys are retarded due to their tendency to brittle destruction and corrosion cracking even in weakly corrosive media (for example, in industrial atmospheres).

Therefore, insufficient studies of the corrosion-mechanical properties, especially of resistance to corrosion cracking, of titanium, aluminum and their alloys, creates obstacles to their wide introduction when developing new structural components and when replacing traditional structural materials by more progressive ones in various industries.

In most cases, the role of certain factors was established unambiguously or tentatively and hypotheses were proposed on the role of these factors in the process of corrosion cracking. However, the development of the corrosion cracking theory of titanium and aluminum alloys still requires further long and intensive investigations.

While problems of metal chemistry, metallurgy and processing titanium, aluminum and their alloys, and their physical and mechanical properties are described in detail in papers of domestic and foreign investigators, publications dedicated to the corrosion-mechanical resistance of these materials, in particular, to corrosion cracking, are not of generalized nature and are presented primarily in the form of individual articles.

An attempt was made in this book to generalize the accumulated data on investigations of corrosion cracking of titanium and aluminum alloys, inasmuch as the separation of the publications makes it difficult to select material properly and carry out work on developing new alloys for actual operating conditions.

We ask that comments and requests be sent to: 252601, Kiev, GSP, Kreshchatik, 5, izdatel'stvo "Tekhnika".

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TITANIUM

UDC 621.791.01:669.295

METALLURGY AND TECHNOLOGY OF WELDING TITANIUM AND ITS ALLOYS

Kiev METALLURGIYA I TEKHNOLOGIYA SVARKI TITANA I YEGO SPLAVOV in Russian, 1979 signed to press 16 Feb 79 pp 5-8, 298-299

[Foreword and table of contents from book edited by S. M. Gurevich, doctor of technical sciences, professor, Naukova Dumka, 2600 copies, 299 pages]

[Text] Modern technology makes greater demands on metallurgical materials. Materials and alloys are needed that are stronger at normal and high temperatures, with adequate ductility and malleability; stable against corrosive media and they must also have special properties.

Among new structural materials that industry assimilated in recent years and that satisfy these demands to a considerable extent titanium and its alloys hold a special place. The constantly widening use of titanium in various sectors of engineering is due to a favorable combination of its physio-chemical properties and, especially, its high unit strength (ratio of its ultimate strength to its specific gravity). This titanium indicator is one of the highest for structural materials.

The excellent corrosion resistance of titanium under atmospheric conditions, to sea water, and a number of corrosive media is the reason for its efficient use to manufacture structural components that operate under the most severe conditions.

Titanium is one of the most widespread elements. It is in fourth place by content in the earth's crust after aluminum, iron and magnesium. Until recently, titanium was used in comparatively small quantities as an alloying additive to ferrous metals -- steels and cast irons. This is because titanium metallurgy has special features and obtaining compact titanium is a complicated process.

In spite of the fact that titanium was discovered in 1790, its use as an independent structural metal and as a basis for alloys began very recently, only several decades ago, after successes achieved in the metallurgy of active metals and alloys. Titanium and its alloys are used in aeroplane building, chemical machine building and in many other fields of production where their specific properties can be used most efficiently. The basic directions for developing the national economy of the USSR in 1976-1980, adopted by the 25th party congress, specify an increase in titanium production in our country by 1.4 times. Due to such a considerable increase in semifinished products made of titanium, its use in various sectors of industry will expand still further.

Along with the continuous increase in the production of titanium alloys, their quality is also improving. As a result of a sharp reduction in harmful admixtures and gases, the ductility and malleability of titanium and its alloys increased and their sensitivity to notching and other defects decreased. The improvement in the quality of titanium and its alloys was an important premise for the expansion of their application in the fields of important equipment.

In the initial period of organizing the production of structural components made of titanium, thin sheet metal was used basically. Lately, urgent problems involve the manufacture of titanium alloy products from medium and large thicknesses of material.

Industrial titanium (σ_B = 35 to 45 kg-force/mm^2) and its low-alloys (σ_β = 80 to 90 kg-force/mm^2) are most widely used in machine-building at home and abroad. At present, various titanium alloys are being developed for various purposes and are used in industry: structural components, refractory, for operation at low temperatures, corrosion-resistant, etc. Thermally strengthened high alloys of titanium that make it possible to take the fullest advantage of such types of alloys are very promising.

To a great extent, the volume of industrial utilization of titanium alloys depends on the successful assimilation of their welding which, however, involves serious difficulties. These are due to the high chemical activity of titanium at high temperatures, especially in the molten state, with respect to atmospheric gases, high melting temperature and other physical properties, as well as to structural transformations in the seam and the zone near the seam at the welding thermal cycle, which frequently lead to the formation of brittle phases.

In recent years, the theory and practice of using various structural components made of titanium and its alloys has developed intensively. A complex of most important problems in the field of metallurgy and welding technology of titanium was solved and described in papers by domestic and foreign investigators.

A considerable contribution to the creation of scientific bases for titanium welding and the development of technological processes for manufacturing welded titanium structural components was made by the Electric Welding Institute imeni Ye. O. Paton AN Ukrainian SSR, the Metallurgical Institute imeni A. A. Baykov AN USSR, the All-Union Aviation Materials Institute and a number of industrial scientific research institutes, laboratories and enterprises.

Among the basic problems solved in the general titanium welding problem are the following: a study of the effect of admixtures -- gases -- in the basic metal on its weldability and allowable limits were established for the admixture content to provide satisfactory weldability of industrially pure titanium and a number of its alloys; requirements were determined of inert gases and welding materials were developed (fluxes, electrode wire, including powder ones) taking into account the physio-chemical properties of titanium; the mechanism of retarded destruction of welded joints of titanium alloys was investigated and efficient measures were developed to prevent the origination of cracks and other defects in the seam and in the zone near the seam; the effect of the alloying elements on the structure and properties of welded titanium seams was established; weldability of various types of titanium alloys was studied and satisfactory weldable alloys were selected; optimal conditions were found for welding titanium of various thicknesses and the behavior of welded joints under operating conditions of products was studied thoroughly.

The results obtained in solving the indicated basic problems make it possible to create reliable technological processes to weld products for various purposes from titanium alloys. The accumulated experience of their operation indicates that welded joints in titanium and many of its alloys provide high structural strength of the products and can withstand not only static but also vibration and dynamic loads.

In the initial period of the industrial assimilation of the production of welded structural components made of titanium, a welding method by fusing in a medium of inert gases with a basically nonmelting electrode was used. At present, practically all known welding methods by fusion (with the exception of manual welding with individual electrodes), as well as contact welding and solid state welding are used for titanium.

Serious difficulties were encountered in developing welding processes for titanium and other metals. However, new approaches and welding techniques make it possible to solve these problems also in a number of cases.

Many papers published in domestic and foreign technical literature are dedicated to the special features of welding titanium and its alloys.

The aim of this book is to systematize information on weldable titanium alloys, generalize the problems of metallurgy and consider in every possible way the means for obtaining good quality welded critical structural components of this new metal.

At the basis of this monograph are the results of many years of investigations conducted by the authors in the department of physio-metallurgical welding processes of chemically active and refractory metals and alloys of the Electric Welding Institute imeni Ye. O. Paton AN Ukrainian SSR. Domestic and foreign technical literature materials were also used.

The book was written by a collective of authors: Ch. 1 -- S. M. Gurevich (Sections 1, 2, 3, 4), I. A. Kushirenko (Section 5); Ch. II -- V. N. Zamkov (Sections 1, 2, 3), S. M. Gurevich (Section 2), N. A. Kushirenko (Section 4); Ch. III -- V. Ye. Blashchuk (Section 1), V. N. Zamkov, N. A. Kushirenko (Sections 2,4), S. D. Zagrebenyuk (Section 3); Ch. IV -- V. P. Prilutskiy, V. N. Zamkov (Section 1), V. Ye. Blashchuk (Sections 1, 2, 3); Ch. V -- S. M. Gurevich (Section 1), S. D. Zagrebenyuk (Section 2), V. N. Zamkov, V. P. Pributskiy (Sections 3,4); Ch. VI -- Ya. Yu. Kompan; Ch. VII -- S. M. Gurevich (Sections 1, 2, 3), V. Ye. Blashchuk (Section 4); Ch. VIII -- V. B. Volkov; Ch. IX -- G. K. Kharchenko; Ch. X -- V. K. Sabokar (Sections 1, 2, 5), G. K. Kharchenko (Section 3), S. M. Gurevich (Section 4); Ch. XI -- V. Ye. Blashchuk (Section 1), S. M. Gurevich (Sections 2,3), N. A. Kushnirenko (Section 2), V. B. Volkov (Section 4).

The authors hope that this book will facilitate the further expansion in fields where titanium and its alloys are used in the industry for welding structural components.

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